THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

AFAPL-TR-73-97

AD 923350

EFFECT OF FUEL ADDITIVES ON THE PERFORMANCE OF FILTER-SEPARATORS

PAUL C. LINDER

TECHNICAL REPORT AFAPL—TR—73—97

AUGUST 1974

Distribution limited to U.S.Government agencies only; Test and Evaluation; August 1974. Other requests for this document must be referred to AFAPL/SFF.

AIR FORCE AERO PROPULSION LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT—PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Proprietary names are used in this report to identify specific equipment or material used in the investigation. Test conditions exceeded the equipment design limitations in some respects. Any failure to withstand the tests to which they were subjected is no reflection on any of the items discussed herein or on any manufacturer.

AFAPL-TR-73-97

EFFECT OF FUEL ADDITIVES ON THE PERFORMANCE OF FILTER-SEPARATORS

Paul C. Linder

Distribution limited to U. S. Government agencies only;
Test and Evaluation; August 1974. Other requests for
this document must be referred to AFAPL/SFF.

FOREWORD

This report was prepared by the Fuels Branch, Fuels and Lubrication Division, Air Force Aero Propulsion Laboratory and is documented under Project 3048, Task 304805. The work was performed in-house by Air Force personnel using the facilities of the Air Force Aero Propulsion Laboratory. The Air Force Project Engineer for this program was Paul C. Linder, (AFAPL/SFF). This work was accomplished over the period July 1969 to June 1972.

This program was initiated to determine the effect of fuel additives on filter-separator performance and to develop a small-scale test method that can be used in the specification testing of corrosion inhibitors.

The author expresses his thanks to Richard Miller, the Test Foreman assigned to this area, and his Technicians, Carl Hoke, Jack Davis, Alfred Strouse, Elbert Stewart, Aston Sayre, Melvin Russell, Timothy Gootee, Richard Homer, Waldell Milley and Joseph Wilbur, who conducted the tests and obtained the required data.

This report was submitted September 1973.

This technical report has been reviewed and is approved.

Arthur V. Churchill
ARTHUR V. CHURCHILL
Chief, Fuels Branch
Fuels and Lubrication Division

AFAPL-TR-73-97

ABSTRACT

The effects of fuel corrosion inhibitors on the coalescing performance of filter-separators were evaluated using a small 1.3 gpm test loop. These tests showed that corrosion inhibitors presently qualified to MIL-I-25017 differed significantly in their deleterious effects on coalescence when tested using Wright-Patterson AFB tap water as the free water contaminant.

Single element tests using DoD standard filter-coalescer elements and a 20 gpm test loop showed: (1) filtration performance is affected by the type of solid contaminant used, the type and quantity of corrosion inhibitor, and the brand of filter-coalescer element used; and (2) coalescence performance can be significantly affected by the purity of free water (i.e., dissolved solids) when the fuel contains a corrosion inhibitor and fuel system icing inhibitor.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I

INTRODUCTION

Fuel serviced to aircraft must be clean and free of water. Solid contaminants in fuel can cause rapid wear and malfunction of fuel system components and other critical engine parts. Free water in the fuel, i.e., undissolved water, can freeze and plug filters, cause fuel control malfunctions, and can result in engine flameouts. Free water in the aircraft fuel tanks can also accelerate corrosion and promote the growth of micro-organisms.

For approximately 20 years the Air Force has relied primarily upon filter-separators to remove solids and free water contaminants from jet fuels prior to servicing aircraft. To remove free (undissolved) water and solids from fuels, filter-separators use two types of elements. The fuel first passes through the filter-coalescer element which removes solid particulate matter by depth filtration. This element also coalesces free water; i.e., small water droplets suspended in the influent fuel are joined together into larger water drops, most of which are subsequently separated from the fuel by gravity.

The second element type is the water separator element (or canister). This element consists of a hydrophobic (water repelling) membrane. Water drops which remain suspended in the fuel following the filter-coalescer element are stripped from the fuel provided the drops are larger than the membrane pores. However, if the filter-coalescer element malfunctions and allows many small drops of water to reach the water separator element, the water may coat the water separator element until differential pressure builds up to the point where the water is forced through the hydrophobic membrane.

Filter-coalescer elements are expendable and must be replaced periodically. Water separator elements may be either "permanent" or "expendable" construction. The permanent elements are often called canisters and usually are fabricated of Teflon-coated metal screen.

Currently, filter-separators are qualified to Specification MIL-F-8901B which specifies the general requirements and test procedures for filter-separators. All filter-separators procured by the Air Force within the past five years use filter-coalescer elements which conform to Specification MIL-F-52308. These are the DoD Standard Elements and conform to specific dimensions for standardization purposes but their performance is specified by MIL-F-8901.

Specification MIL-F-8901 requires qualification tests for all approved elements. Only one of the tests required by MIL-F-8901 uses a jet fuel containing corrosion inhibitor additives. Yet all JP-4 fuel procured for the Air Force contains corrosion inhibitors (conforming to MIL-I-25017) and the fuel system icing inhibitor (FSII) conforming to MIL-I-27686. Presently there are eleven approved corrosion inhibitors which may be added to JP-4 fuel. Previous work (References 1 and 2) has shown that corrosion inhibitors can degrade filter-separator performance but there are insufficient controls to prevent this from happening.

Thus, the purpose of this program was twofold: (1) to determine the effect of current corrosion inhibitors on the performance of existing filter-separators, and (2) to evaluate test procedure variables.

SECTION II

DESCRIPTION OF EQUIPMENT

1. TEST EQUIPMENT

a. 20 Gallon Per Minute Test Loop

The 20 gpm test loop was designed and constructed by Southwest Research Institute for the Air Force and is thoroughly described in References 3, 4, and 5. For this series of tests, however, the following modifications have been made: (1) installation of a Potter turbine flow meter with strip chart recorder for continuously recording the fuel flow rates; (2) the use of a small 5 gpm centrifugal pump to disperse free water added to the fuel as a test contaminant; and (3) changing the sump drain on the test housing from under the element to the side of the housing so that possible vortexing in the sump would be prevented.

b. 1.3 Gallon Per Minute Test Loop

A small 1.3 gpm loop was designed and constructed to allow a rapid screening of fuel additives and their effects on the water coalescing performance of filter-separators. This loop was needed as the 20 gpm loop was designed primarily for recirculatory type tests and an additional fuel trailer would be required to provide additional fuel storage capacity when conducting one-pass tests. See Figure 1 for a schematic diagram of the 1.3 gpm test loop. This loop used a small filter-coalescer element. This element is simply a 2-inch segment of a standard DoD element (MIL-F-52308) that meets the requirements of MIL-F-8901B. This particular element was selected because of its availability and it was believed to be representative of filter-coalescer elements currently in use. Although the element is one-tenth the length of the DoD element, the end caps reduce the effective filter area to about 6.5% of that of a regular element. As the rated flow of the DoD element is 20 gpm, the 2-inch segment was rated at 1.3 gpm (0.065 X 20 gpm). A photograph of this element is shown in Figure 2.

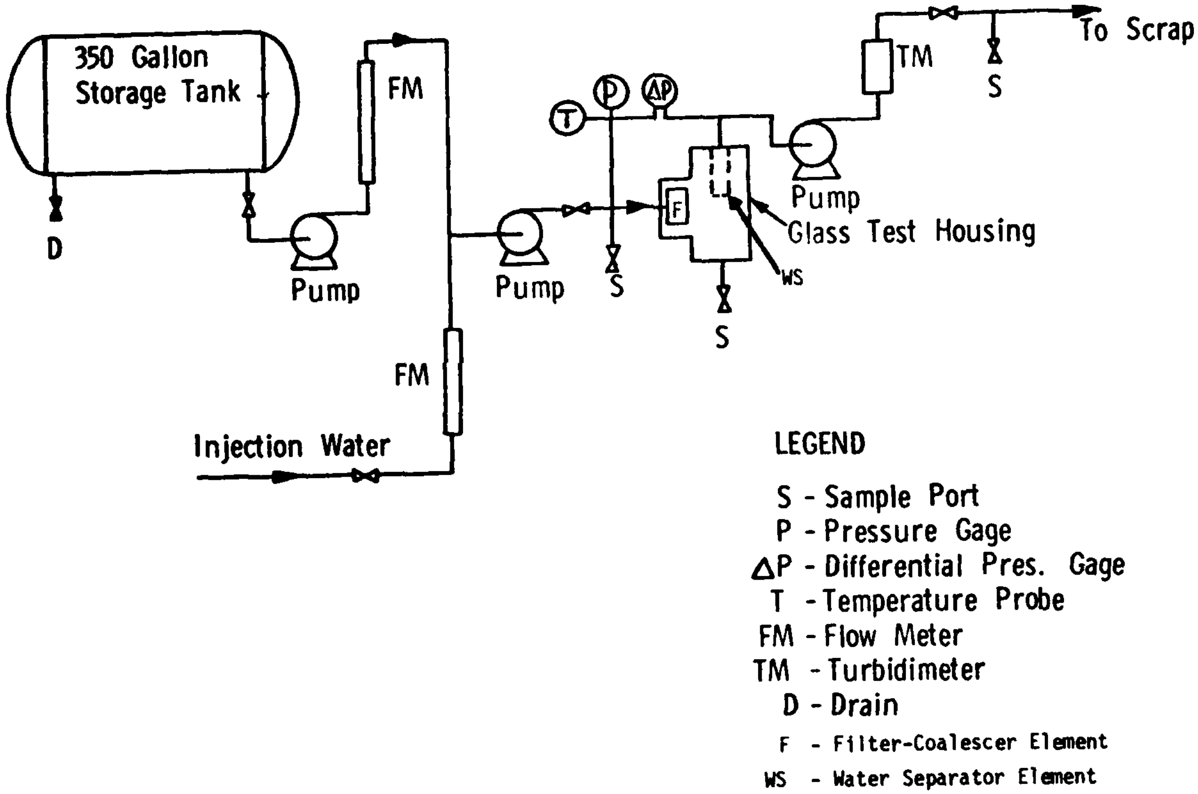

Figure 1. Schematic Diagram of the 1.3 GPM Test Loop

Figure 2. Photograph of the Filter-Separator Element Used in the 1.3 GPM Test Loop

A 6-inch diameter glass tee was used as the filter-separator test vessel for the 1.3 gpm loop. The glass tee gave a visual observation of the filter-coalescer and the water-separator element performance. The glass tee was mounted as shown in Figure 3 with the fuel entering from the side, through the filter-coalescer element, and exiting at the top through the water-separator element. The water-separator element was fabricated of Teflon-coated, metal screen and was obtained from a 10 gpm filter-separator. The bottom leg of the tee served as the water sump and was fitted with a valve so that separated free water could be drained.

The fuel velocities in the glass tee vessel were much lower than are generally found in full-scale filter-separators. This provided a longer residence time for the test fuel and allowed smaller water drops to fall to the sump than would have occurred in a full-scale filter-separator. This, in turn, decreased the load on the water-separator element. Thus, the 1.3 gpm filter-separator was very conservative in design and would not be expected to give as severe a test as a full-scale filter-separator.

The 1.3 gpm loop was designed for one man operation. All controls and gauges are placed so that one man can operate the controls, take samples, and record the pressure and flow data. Figure 4 is a photograph of the control panel and test housing of the 1.3 gpm test loop.

The 1.3 gpm test loop was connected to the 20 gpm loop permitting the use of the clean-up filter separator, clay filter, and the two 600 gallon tanks for water washing and clay treating the fuel prior to use. The 20 gpm loop was also used for corrosion inhibitor blending and for temporary fuel storage. The increased flexibility provided by the 20 gpm loop permitted the use of a baseline test prior to the inhibited fuel test. This was a simple coalescence test using uninhibited fuel to insure that the initial performance of the test filter separator element was satisfactory.

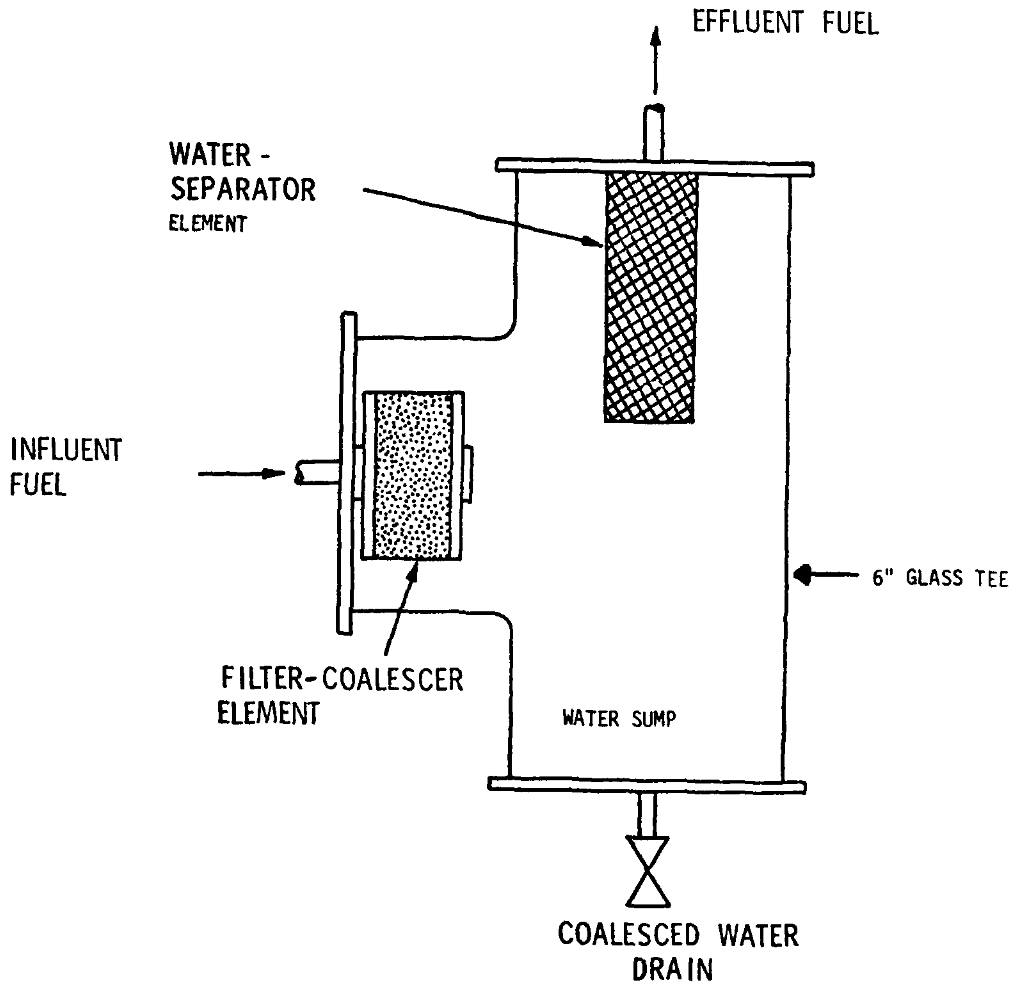

Figure 3. Glass Test Housing for the 1.3 GPM Test Loop

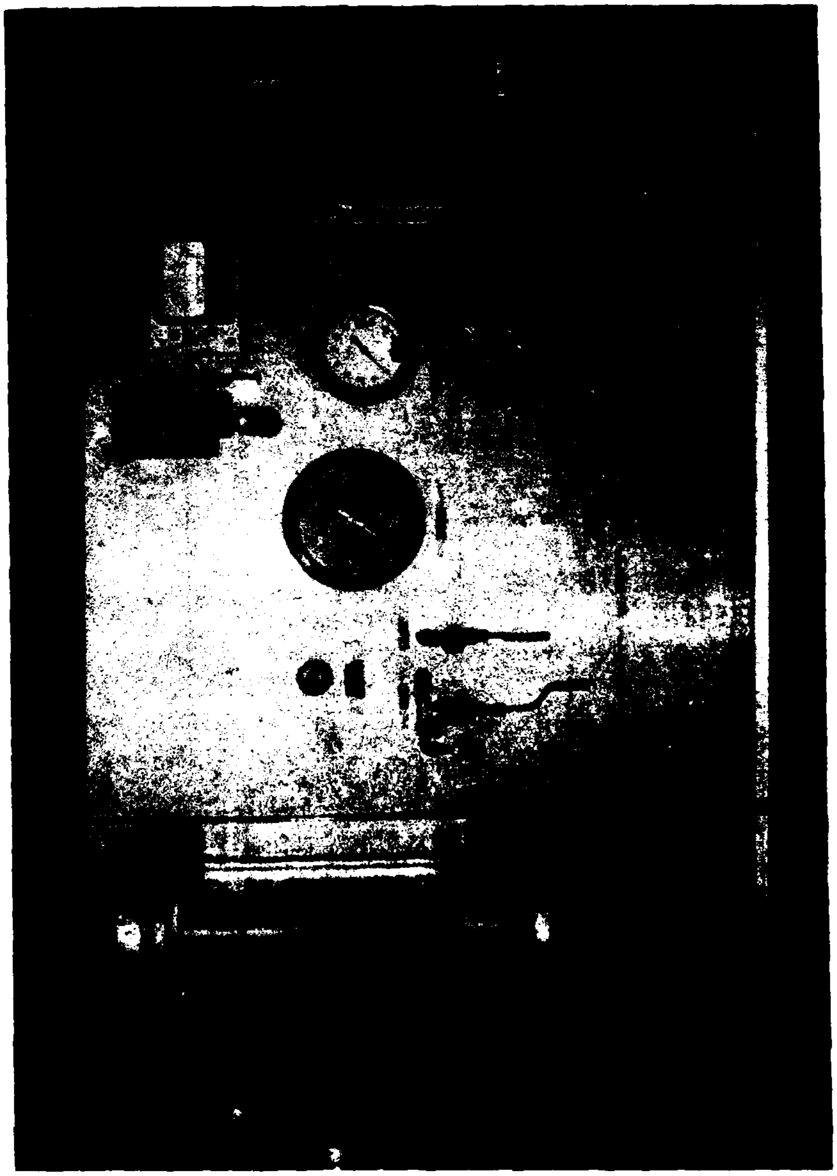

Figure 4. Photograph of the Test Panel and Test Housing of the 1.3 GPM Test Loop

c. Measurement and Laboratory Equipment

A Keene Turbidimeter, Model 861B-2015T, was installed downstream of the test housing in both loops and was used as the primary continuous free water measurement instrument. Since this Turbidimeter measures in Jackson Turbidity Units, it was periodically calibrated to obtain an accurate conversion chart to give the free water content in milligrams per liter. The Turbidimeter is the method used in MIL-F-8901 for determining pass-fail criteria for filter-separator coalescence performance. A failure is a sustained reading of more than 5 ppm of free water for one minute. The free water content was also measured by the fluorescein dyed-pad method using either the Gammon Aqua-Glo Series II or the AEL Free Water Detector. Both the Turbidimeter and the dyed pad methods have some disadvantages. The accuracy of the Turbidimeter is affected by the size of the free water drops and by the air and solids suspended in the fuel; the dyed-pad method is affected by the additives in the fuel. In the 1.3 gpm loop, an attempt was made to insure good dispersion of any free water present by installing a small centrifugal pump (Eastern Model D-11) between the test housing and the Turbidimeter. This substantially increased the Turbidimeter readings and brought them into closer agreement with the Aqua-Glo readings.

For satisfactory filtration performance, MIL-F-8901 requires that the effluent fuel contain no more than 0.5 mg of solids per liter of test fuel, on the average, and no more than 1.0 mg per liter of solids for any one test. This test is run using inhibited test fuel (i.e., fuel containing Hitec E-515 corrosion inhibitor). The effluent fuel is sampled for solids content four times during the test while solids are purposely being added to the test fuel.

All laboratory tests, including the determination for solids content of fuel, the fuel system icing inhibitor (FSII) concentration, water separometer index modified, and interfacial tension measurements were conducted using the methods described in Reference 3.

2. TEST ELEMENTS

The following filter-separator elements were used in this program:

(1) I-4208, a MIL-F-52308 element manufactured by Velcon Filters, Inc., and qualified to MIL-F-8901A.

(2) TE-497, a special element supplied by Velcon Filters, Inc., for red iron oxide (RIO) removal meeting the size and flow requirements of MIL-F-52308.

(3) TEO-71, a special over-size element for RIO removal supplied by Velcon Filters, Inc.

(4) 045800-04, a MIL-F-52308 element manufactured by Bendix Filter Division and qualified to MIL-F-8901A.

(5) 045800-10, a MIL-F-52308 element manufactured by Bendix Filter Division and qualified to MIL-F-8901B.

(6) 057032, a special element supplied by Bendix Filter Division for the 1.3 gpm test loop; actually a two inch long section of the 045800-04 element.

(7) C-2037-3, a MIL-F-52308 element manufactured by Banner Engineering Corporation and qualified to MIL-F-8901B.

(8) 600343, a MIL-F-52308 element manufactured by the Keene Corporation and qualified to MIL-F-8901B.

SECTION III

TEST FUELS

1. FUEL TYPE

Most tests were conducted with JP-5 fuel meeting the requirements of MIL-T-5624. The test fuel was first purified to remove any existing surfactants. This was accomplished by water washing with two percent water, passing the fuel through filter-separators, and finally clay filtering. If required, 0.15 percent fuel system icing inhibitor was then blended into the fuel along with the required amount of corrosion inhibitor.

Six tests were run with MIL-T-38219 grade JP-7 fuel. There was no pre-treatment of this fuel. In two runs with JP-7, a thermal stability additive, DuPont JFA-5, was added to the fuel.

2. FUEL ADDITIVES

Most of the additives tested in this program were fuel soluble corrosion inhibitors, qualified to Military Specification MIL-I-25017C. Any one of these inhibitors is normally added to all JP-4 turbine engine fuels delivered to the Air Force. Table I lists these inhibitors along with their relative effective, minimum effective, and maximum allowable concentrations. The relative effective is that concentration required to pass the corrosion test of MIL-I-25017, and the minimum effective is the minimum quantity the refiner must add to the fuel. Most of the testing was conducted at the maximum allowable concentration with the concentration being lowered until a pass was obtained.

All the fuels, except on non-additive tests, contained 0.15% fuel system icing inhibitor per MIL-I-27686, which is ethylene glycol monomethyl ether.

TABLE I

MIL-I-25017 CORROSION INHIBITORS

Concentrations in Pounds per 1000 Barrels

Material	Supplier	Relative Effective	Effective Minimum	Maximum Allowable
HITEC E-515 (Santolene C)	Edwin Cooper	5	7 1/2	16
HITEC E-534 (Santolene CM)	Edwin Cooper	2	3	8
AFA-1	DuPont	3	4 1/2	12
5400 (D-2100)	Nalco	3	4 1/2	12
5401 (D-2101)	Nalco	3	4 1/2	12
PRI-19	Apollo	2	3	4
541	Lubrizol	2	3	6
Tolad 244	Petrolite	3	4 1/2	6
Tolad 245	Petrolite	5	7 1/2	12
T-60	Conoco	4	6	16
Unicor J	Universal Oil Prod.	2	3	8
DCI-4A	DuPont	2	3	8

3. FUEL CONTAMINANTS

To test the performance of filter-separators, known amounts of solid matter and free water are added to the test fuel. The types of solids and the types of water added to the fuel as test contaminants are described below.

a. SOLIDS. Three types of solid contaminants were used in this work: Standard A.C. Coarse Dust, Standard A.C. Fine Dust, and a Coarse Red Iron Oxide (RIO).

The Standard A.C. Coarse Test Dust is the contaminant specified for the inhibited fuel test in MIL-F-8901. It is a siliceous "Arizona road dust" having a particle size distribution of 1 to 200 microns and has been collected and standardized for use in testing air cleaners and filters. It is available from the A.C. Spark Plug Division, General Motors Corporation, Flint, Michigan, and is identified as Part Nr. 1543637. The Fine A.C. Dust, prepared from the coarse by screening out all the particles over 100 microns, is available from the same source.

The Pfizer R-9998 Coarse Red Iron Oxide (RIO) was chosen for some tests in lieu of the Fisher I-116 RIO which is specified in MIL-F-8901. The Fisher I-116 RIO is mostly sub-micronic in particle size and is not believed to be a realistic test contaminant. The Pfizer R-9998 RIO largely consists of particles in the 1 to 10 micron range, and closely approximates the contamination found in pipelines. The R-9998 Red Iron Oxide is available from Pfizer Minerals, Pigments, and Metals Division, Pfizer, Inc., 235 E. 42nd Street, New York, N. Y. 10017.

Complete particle size distributions of these test dusts are given in Table II.

b. INJECTION WATER. Three different waters were added to the test fuel as a test contaminant for filter-separator testing. These were WPAFB, Ohio, tap water; Fort Belvoir, Virginia, tap water; and distilled water.

TABLE II

PARTICLE SIZE DISTRIBUTION OF TEST DUSTS

	Standard AC Test Dust (%)		Red Iron Oxide (%)	
	Coarse	Fine	Pfizer R-9998	Fisher I-116
Weight % Below 200 μ	100			
80	91	100		
40	61	91		
20	38	73		
15			100	100
10	24	57	99.3	100
7.5			98.3	99.7
5	12	39	84.9	98.9
4			74.5	98.2
3	8	21	25.2	97.9
2	5	11	7.3	97.1
1			5.6	94.1
0.5			4.9	77.7
0.25				47.8

The WPAFB tap water was used for all tests on the 1.3 gpm loop and on the 20 gpm single element tests through run Nr. 201. This water is genuinely hard water from shallow wells with no treatment except for chlorination to 0.4 ppm by gas injection. This water was classified as Type C hard water and contains about 550 ppm total dissolved solids.

Fort Belvoir tap water was used only for correlation tests at Fort Belvoir, Virginia, and not in any loop tests at WPAFB. This water approximates a Type B hard water and has a dissolved solids content of 100 ppm. An analysis of both of these waters is presented in Table III. An analysis of the distilled water was not made.

The type of water contaminant proved to be a major factor in filter test failures rather than specific filter materials or construction.

TABLE III

TAP WATER ANALYSIS

PROPERTY	FT. BELVOIR	W-PAFB
Total Solids, ppm	115	567
pH @ 25°C	7.0	7.6
Sulfates	Absent	Present
Total Acidity, mg/liter	4.8	6.6
Halogens, mg/liter	0.8	64.6
Total Hardness, mg/liter as $CaCO_3$	54	516
Calcium Hardness, mg/liter as $CaCO_3$	53	241
Magnesium Hardness, mg/liter as $CaCO_3$	Negligible	275

SECTION IV

TEST PROCEDURES AND RESULTS

1. TEST PROCEDURE 13-A

The first procedure used in the 20 gpm test loop was developed by Southwest Research Institute and designated 13-A (Reference 3). This procedure used a fuel flow rate of 20 gallons per minute with a water injection rate of 0.01% and a solids injection rate of 5.72 grams per minute of A.C. Coarse Test Dust. After a pressure differential (ΔP) across the test element of 20 pounds per square inch was reached, the solids injection was cut off and the water rate was increased to 1.0%. This was held for 15 minutes, then solid injection was restarted until a pressure differential of 40 pounds per square inch was reached. See Table IV for a summary of this procedure. The data obtained using this procedure (See Table V) has limited validity because of the following factors: (a) the fuel was recirculated with only 600 gallons being used which gives a possibility of additive depletion; (b) a significant water injection rate of 1% is not obtained until after a pressure drop across the element of 20 psi is reached; and (c) the effluent fuel solids content is biased as samples for solids analysis are taken with filter-separator differential pressures up to 40 psi, yet in normal use the elements are changed when the pressure differential reaches 20 psi.

One significant item can be derived from these runs using Procedure 13-A; the corrosion inhibitors used in jet fuels reduce the solids capacity of filter-separators significantly. As shown in Table VI, the average solids holding capability of a Velcon I-4208 element was greatly reduced. The addition of 0.15% Fuel System Icing Inhibitor (Ethylene Glycol Monomethyl Ether) caused an insignificant decrease in capacity. While the average solids capacity of filter-separator elements is reduced by the fuel additives, the elements still pass the MIL-F-8901 requirement that each element hold a minimum of 200 grams of A.C. Coarse Dust before a pressure drop of 40 psi is reached.

TABLE IV

TEST PROCEDURES USED WITH THE 20 GPM TEST LOOP

Procedure	Fuel Flow Rate (gpm)	Time (Min)	Water Injection Rate (Vol. %)	Solids Injection Type Solids	Solids Injection Injec. Rate (grams/min)	Remarks
13-A	20	0 to 20 psi ΔP	0.01	AC Coarse	5.72 grams/min	See Reference 3 for additional details.
		20 psi ΔP to + 15 min	1.0	None	None	
		20 psi ΔP + 15 min to 40 psi ΔP	1.0	AC Coarse	5.72 grams/min	
13-J	Same as 13-A except for Solids			AC Fine	Same as 13-A	See Reference 3
13-M	Same as 13-A except for Solids			R-9998 RIO	Same as 13-A	See Reference 3
8901	20 gpm	0-60	1%	None	None	This is actually a modified 8901 due to use of R-9998 RIO. Where only the 1st hour is run this implies only the 0-60 min run with 1% water, no solids.
		60-130 or to 40 psi ΔP	1%	R-9998	2.86 grams/min	

TABLE V

SUMMARY OF TEST RESULTS - 20 GPM TEST LOOP

RUN NR.	TEST PROCEDURE	ADDITIVE	CONCENTRATION LBS/1000 BBLS	ELEMENT	SOLID CONTAMINANTS	MAX H_2O PPM	SOLIDS (MG/L) AVG.	SOLIDS (MG/L) MAX.	% SOLIDS HOLDING CAP.
901	13-A	Santolene C	16	I-4208	A. C. Coarse	1	0.18	0.26	117
902	13-A	Santolene C	16	I-4208	A. C. Coarse	0	0.12	0.32	120
903	13-A	AFA-1	16	I-4208	A. C. Coarse	1	0.26	0.46	149
904	13-A	AFA-1	16	I-4208	A. C. Coarse	9	0.29	0.58	154
905	13-A	JP-7 Fuel	0	I-4208	A. C. Coarse	0	0.05	0.09	237
906	13-A	JP-7 Fuel	0	I-4208	A. C. Coarse	0	0.01	0.02	251
909	13-A	D-2100	12	I-4208	A. C. Coarse	4	0.11	0.21	131
910	13-A	D-2100	12	I-4208	A. C. Coarse	1	0.14	0.21	171
911	13-A	D-2100	12	I-4208	A. C. Coarse	1	0.24	0.52	123
916	13-A	PRI-19	12	I-4208	A. C. Coarse	4	0.20	0.58	114
917	13-A	PRI-19	12	I-4208	A. C. Coarse	3	0.27	0.47	103
918	13-A	PRI-19	12	I-4208	A. C. Coarse	3	0.47	0.57	103
919	13-A	Tolad 245	20	I-4208	A. C. Coarse	11	1.30	1.71	121
920	13-A	Tolad 245	20	I-4208	A. C. Coarse	3	0.66	0.87	89
921	13-A	Tolad 245	20	I-4208	A. C. Coarse	3	0.67	1.05	94
922	13-A	Lub 541	8	I-4208	A. C. Coarse	6	1.27	1.63	106
923	13-A	Lub 541	8	I-4208	A. C. Coarse	5	0.71	0.88	110
924	13-A	Lub 541	8	I-4208	A. C. Coarse	2	0.43	0.62	91
925	13-A	None	0	I-4208	A. C. Coarse	0	0.03	0.06	226
926	13-A	None	0	I-4208	A. C. Coarse	0	0.04	0.16	258
927	13-A	None	0	I-4208	A. C. Coarse	0	0.00	0.00	237
928	13-A	None	0	I-4208	A. C. Coarse	0	0.03	0.07	233
930	13-A	AFA-1	16	I-4208	A. C. Coarse	5	0.09	0.13	127
931	13-A	Santolene C	16	I-4208	A. C. Coarse	3	0.04	0.08	110
932	13-A	Tolad 244	12	I-4208	A. C. Coarse	11	0.37	0.92	88
933	13-A	Tolad 244	12	I-4208	A. C. Coarse	30	0.26	0.57	121
934	13-A	Tolad 244	12	I-4208	A. C. Coarse	1	0.00	0.00	187
935	13-A	JP-7	0	I-4208	A. C. Coarse	0	0.04	0.11	249
936	13-A	JP-7	0	I-4208	A. C. Coarse	0	0.00	0.00	216
937	13-A	JFA-5 in JP-7	8	I-4208	A. C. Coarse	2	0.05	0.12	182
938	13-A	JFA-5 in JP-7	8	I-4208	A. C. Coarse	1	0.01	0.04	157

TABLE VI

PROCEDURE 13-A

AVERAGE SOLIDS CAPACITY OF AN I-4208 ELEMENT WITH VARIOUS ADDITIVES

Additive	Average Solids Capacity in Grams at 40 psi
None	484
FSII	470
Santolene C	232
DuPont AFA-1	286
NALCO 5400	284
Apollo PRI-19	214
Tolad 245	202
Tolad 244	264
Lubrizol	204

2. TEST PROCEDURE 13-J

This procedure is similar to 13-A except that fine A.C. Test Dust is used as a solid contaminant instead of Coarse A.C. Test Dust. (See Table IV). Southwest Research Institute (SwRI) had shown that with the maximum concentration of a corrosion inhibitor in the fuel, the element would not hold 200 grams of Fine A.C. Test Dust before a 40 psi pressure differential is reached (Reference 3). Run Nr. 939 (Table VII) was made without an additive and showed a solids capacity of 522 grams (261% of rated capacity). Two runs were then made on each of three corrosion inhibitor additives at the minimum concentration of 4 lbs/1000 bbls (Runs Nr. 940-945, Table VII). These runs showed solid capacities from 130 to 190 grams (65% to 95% of rated capacity). This indicates that a corrosion inhibitor will cause caking of the finer size particles with drastically reduced solids capacity of the element.

3. SPECIAL ELEMENTS FOR RED IRON OXIDE REMOVAL

Previous work by SwRI (Reference 3) and others has shown that filter-separator elements are not capable of removing red iron oxide from fuels containing corrosion inhibitors.

In the MIL-F-8901 Non-Additive Tests, Fisher I-116 red iron oxide is used. This finely divided red iron oxide can be removed from the non-additive fuel because the particles will agglomerate together into large particles which allows the filter-separator element to remove them. However, when a corrosion inhibitor is present, the particles will not agglomerate together and much of the red iron oxide will pass through the filter element. As the Air Force JP-4 fuel normally contains a fuel corrosion inhibitor additive, a previous program had evaluated special elements conforming to the MIL-F-52308 dimensions but with superior filtration performance (Reference 3). Pfizer R-9998 red iron oxide was chosen as the test contaminant because its particle sizing was closer to the iron oxide found in pipelines.

TABLE VII

SUMMARY OF TEST RESULTS - 20 GPM LOOP

RUN NR.	TEST PROCEDURE	ADDITIVE	CONCENTRATION LBS/1000 BBLS	ELEMENT	SOLID CONTAMINANTS	MAX H_2O PPM	SOLIDS (MG/L) AVG.	SOLIDS (MG/L) MAX.	% SOLIDS HOLDING CAP.
939	13-J	None	0	I-4208	A. C. Fine	0	0.08	0.19	261
940	13-J	Santolene C	4	I-4208	A. C. Fine	1	0.00	0.00	86
941	13-J	Santolene C	4	I-4208	A. C. Fine	1	0.00	0.00	95
942	13-J	AFA-1	4	I-4208	A. C. Fine	2	0.58	1.51	73
943	13-J	AFA-1	4	I-4208	A. C. Fine	3	2.48	8.14	77
944	13-J	D-2100	4	I-4208	A. C. Fine	3	0.66	1.82	65
945	13-J	D-2100	4	I-4208	A. C. Fine	1	0.28	0.38	89
946	13-M	AFA-1	10	TEO-71	R-9998	15	0.08	0.26	234%
949	13-M	AFA-1	10	TEO-71	R-9998	8	0.05	0.14	161
950	13-M	Santolene C	12	TEO-71	R-9998	9	0.01	0.02	164

During a previous program, elements were procured from Bendix Filter Division, Keene (Bowser) Corporation and Velcon Filters, Inc. Both the Bendix and Keene elements were found to be about equal to the standard elements for removing RIO (Reference 3). The Velcon element identified as TE-497 was tested in this program in Runs Nr. 907 and 908 using the MIL-F-8901 inhibited fuel procedure except the test contaminant was Pfizer R-9998 (See Table VIII). These elements also allowed the solids to pass through. Velcon then furnished us with another element identified as TEO-71 which was 6-inches in diameter by 20-inches long. While this element is larger in diameter than the MIL-F-52308 element, they stated that this type could be made in the MIL-F-52308 size. Since the element was too large to use the DoD type water-separator canister which surrounds the element, the 8-inch diameter aluminum test housing was modified so that a 6-inch diameter x 10-inch long teflon-coated water-separator canister could be suspended above the element.

Five tests were run with the TEO-71 elements using R-9998 red iron oxide; three (Runs Nr. 946, 949, 950) (See Table VII) using Procedure 13-M which is similar to Procedure 13-A except that R-9998 is used as the solid contaminate instead of Coarse A.C. Dust; and two (Runs Nr. 952 and 953) (See Table VIII) with the MIL-F-8901 inhibited fuel test. In all tests using R-9998, the TEO-71 element reduced the solids content of the effluent fuel to below 0.5 mg/liter which meets the solids removal criteria of MIL-F-8901.

In summary, the Velcon TEO-71 element was shown to be capable of removing the R-9998 red iron oxide when fuel corrosion inhibitors are present.

4. COALESCENCE TESTS WITH THE 1.3 GPM TEST LOOP

Ten MIL-I-25017 corrosion inhibitors were tested for effects on coalescence in the 1.3 gallon per minute small glass loop using the Bendix 057032 elements with 1% tap water from WPAFB as the contaminant. All inhibitors were first checked at their maximum allowable concentration and only three (Hitec E-515, Hitec E-534 and Conoco T-60) passed all the

TABLE VIII

SUMMARY OF TEST RESULTS - 20 GPM LOOP

RUN NR.	TEST PROCEDURE	ADDITIVE	CONCENTRATION LBS/1000 BBLS	ELEMENT	SOLID CONTAMINANTS	MAX. H_2O PPM	SOLIDS (MG/L) AVG.	SOLIDS (MG/L) MAX.	% SOLIDS HOLDING CAPACITY @ 40 psi ΔP	ΔP IN PSI
907	8901	AFA-1	10	TE-497	R-9998 RIO	0	6.12	16.17	9.0	
908	8901	AFA-1	10	TE-497	R-9998 RIO	0	11.83	24.11	15.0	
912	8901	AFA-1	10	I-4208	A. C. Coarse	1	0.23	1.07		14.0
913	8901	AFA-1	10	I-4208	A. C. Coarse	3	0.22	0.93		9.7
914	8901	Santolene C	16	I-4208	A. C. Coarse	3	0.03	0.12		23.5
915	8901	Santolene C	16	I-4208	A. C. Coarse	3	0.03	0.12		31.2
929	8901 WR	None		I-4208	None	3				7.4
952A	8901 1st hr.	Santolene C	12	TEO-71		9				10.5
953A	8901 1st hr.	Santolene C	12	TEO-71		1				14.8
953B	8901 2nd hr.	Santolene C	12	TEO-71	R-9998 RIO	0	0.16	0.37		50.0+
952B	8901 2nd hr.	Santolene C	12	TEO-71	R-9998 RIO	0	0.10	0.24		37.5

tests at this concentration. Tests were then conducted on the remaining additives at lower concentrations to try to determine a level at which the inhibitor would pass the coalescence test. Only one other additive, Apollo PRI-19, gave consistent passes at the lower concentrations tested. There were two passes each at concentrations of 3, 3.7 and 4 pounds per 1000 barrels; however, there also were two failures at the 4 pounds concentration. All concentrations above 4 pounds resulted in failures. The other five inhibitors all failed at and above their relative effective concentrations.

Several of the inhibitors induced very high pressure drops across the filter but there is no apparent correlation between pressure drop and the water removal ability. Table IX lists the data obtained on each run including water-separometer index modified (WSIM) and interfacial tension measurements (IFT's).

5. MIL-F-8901B INHIBITED FUEL TESTS

After the preliminary screening in the small glass loop, final evaluations of the corrosion inhibitors were conducted in the 20 gpm loop using the inhibited fuel test of MIL-F-8901B so that an evaluation could be made using both solids and water contamination. For these tests, DoD Standard (MIL-F-52308) filter elements qualified to MIL-F-8901B and manufactured by the Banner Engineering Corporation were obtained through Air Force supply.

The initial tests with these elements were conducted using 16 pounds per 1000 barrels of fuel of HITEC E-515 (Santolene C) which is the inhibitor used in the MIL-F-8901B qualification test. The first tests (Numbers 110 through 112 of Table X) all failed due to excessive water in the effluent fuel. Test 113 also failed using a MIL-F-8901B element from a different production batch. Test No. 114 was then made without an inhibitor and good coalescence performance was obtained with a Banner element. Test Numbers 115 and 116 were then conducted using a Keene element (600343) and a Velcon element (TE497), respectively, both resulting in poor coalescence performance. (See Table X).

TABLE IX

TEST RESULTS WITH THE 1.3 GPM LOOP

TEST NR.	ADDI-TIVE	CONCENTRATION LBS/1000 BBLS	WSIM BASELINE	WSIM INHIB.	IFT BASELINE	IFT INHIB.	IFT INHIB/ INJ. H_2O	IFT INHIB/ COAL. H_2O	% FSII	MAX H_2O TURBIDO-METER	MAX H_2O AQUA GLO	MAX H_2O AEL	Δ P INIT.	Δ P MAX.
Hitec E-515														
22	A	12	83	78		38.5		14.8	.158	1.9	6		7.2	14.3
28	A	12	91	83	46.7	41.7		16.6	.153	0.3	4		7.8	14.9
50	A	16	99	78	45.5	37.8	21.0	14.2	.140	0.4		3	9.5	25.5
62	A	16	98	84	43.7	37.6	18.7	14.0	.142	0.2	4		7.0	15.0
63	A	16	98	84	43.7	37.6	18.7	14.0	.142	0.1	3		6.0	15.8
Hitec E-534														
52A	B	8	96	85	44.7	39.9	28.0	16.7	.141	1.3	7		8.0	13.5
52B	B	8	92	91	45.0	40.5	24.4	16.3	.132	1.2	1		8.2	13.6
76	B	8	96	86	45.1	40.4	27.4	15.3	.137	0.4	8		7.0	12.8
77	B	8	96	86	45.1	40.4	27.4	15.3	.137	0.3	3		6.0	10.8
Nalco 5400														
31	D	10	92	74				7.2	.136	67.3	30		8.0	9.3
41	D	12	96	89				9.0	.150	15.6		OS*	8.4	8.6
47	D	3	98	84	45.5	37.7	37.8	8.3	.129	10.8		54	9.0	10.2
58	D	3	99	89	45.7	36.7	30.6	8.4	.156	11.4		20	6.7	8.2
60	D	3	98	92	44.8	37.7	31.4	8.6	.154	24.5		45	6.8	8.2
78	D	4 1/2	94	84	41.7	32.4	33.4	6.3	.142	13.3	15+		6.3	8.3
79	D	4 1/2	94	84	41.7	32.4	33.4	6.3	.142	11.2	40		6.0	7.6
Nalco 5401														
33	E	12	98	88				6.1	.147	170.7		OS*	7.4	8.4
43	E	3	98	91		40.9	40.4	12.5	.139	7.1	27		9.2	10.0
61	E	3	100	87	44.2	36.8	34.3	5.3	.150	7.7		11	7.0	8.7
72	E	4 1/2	99	89	46.9	40.7	31.2	7.3	.140	84.7		30	6.5	8.0
73	E	4 1/2	99	89	46.9	40.7	31.2	7.3	.140	98.1		50	7.0	8.3

* OS - Off Scale
Pad too bright to read

TABLE IX (CONTINUED)

TEST NR.	ADDI-TIVE	CONCENTRATION LBS/1000 BBLS	WSIM BASELINE	WSIM INHIB.	IFT BASELINE	IFT INHIB.	IFT INHIB/ INJ. H_2O	IFT INHIB/ COAL. H_2O	% FSII	MAX H_2O TURBIDO-METER	MAX H_2O AQUA GLO	MAX H_2O AEL[2]	Δ P INIT.	Δ P MAX.
DuPont AFA-1														
23	F	12	95	86		25.6		17.7	.161	57.1	16		8.3	11.6
30	F	10	90	68		16.8		15.5	.142	220.1	70		9.0	10.9
40	F	12	98	75				17.6	.147	311.0		75	8.1	9.2
44	F	3	96	92		36.1	35.3	14.8	.140	10.3	6		9.8	11.0
57	F	3	90	89	45.8	40.9	27.9	12.0	.151	4.0		18	7.4	8.9
64	F	4 1/2	93	92	41.4	31.4	27.1	4.1	.134	47.0	32		7.0	8.0
65	F	4 1/2	93	92	41.4	31.9	27.1	4.1	.134	26.5	13		5.8	7.8
Apollo PRI-19														
24	H	12	97	84				19.2	.143	33.2	29		8.5	13.4
35	H	10	91	71				18.0	.113	19.1		25	8.1	13.1
42	H	3	97	93		42.8	39.4	19.6	.126	1.7	4		8.0	10.7
49	H	4	98	90	45.4	39.8	33.6	10.7	.100	7.2		54	8.3	12.3
51	H	3	97	84	45.7	41.5	34.9	15.0	.148	0.2		3	8.4	10.9
54	H	4	92	90	44.8	39.4	24.5	20.1	.149	15.4	12		7.4	11.6
70	H	3.7	97	87	46.3	38.9	31.0	12.0	.144	.3		4	7.0	9.5
71	H	3.7	97	87	46.3	38.9	31.0	12.0	.144	2.8		11	5.5	9.5
82	H	4	92	93	44.0	36.6	32.0	17.1	.145	3.6	11		6.8	10.0
83	H	4	92	93	44.0	36.6	32.0	17.1	.145	1.0	6		6.0	9.0
Lubrizol 541														
25	I	8	97	56				9.1	.147	758.2	30		9.5	22.9
38	I	6	92	79				17.7	.140	225.6		OS*	8.3	16.0
45	I	2	96	91	45.0	41.2	39.9	18.0	.124	12.9	20		9.5	13.4
56	I	2	98	93	45.7	40.4	40.8	11.5	.147	19.1	20		7.4	11.4
66	I	3	97	96	41.4	34.8	25.6	11.7	.144	62.8	65		7.2	12.3
67	I	3	97	95	41.4	34.8	25.6	11.7	.144	40.1	48		6.1	11.5

* OS - Off Scale
Pad too bright to read

TABLE IX (CONCLUDED)

TEST NR.	ADDI-TIVE	CONCENTRATION LBS/1000 BBLS	WSIM BASELINE	WSIM INHIB.	IFT BASELINE	IFT INHIB.	IFT INHIB/ INJ. H_2O	IFT INHIB/ COAL. H_2O	% FSII	MAX H_2O TURBIDO-METER	MAX H_2O AQUA GLO	MAX H_2O AEL	Δ P INIT.	Δ P MAX.
Tolad 244														
27	J	8	97	67				16.7	.146	227.7	OS*		8.3	9.3
39	J	6	96	90		36.5		4.4	.146	191.5		60	7.7	9.2
48	J	3	94	84	44.4	39.1	31.0	8.3	.115	13.4		45	9.7	11.1
59	J	3	98	94	44.3	38.3	27.1	12.3	.153	9.9		30	7.4	8.8
80	J	4 1/2	94	85	44.3	36.0	33.9	10.0	.141	121.5	30		6.5	9.3
81	J	4 1/2	94	85	44.3	36.0	33.9	10.0	.141	11.0	12		5.6	8.0
Tolad 245														
26	K	20	98	78				13.2	.145	185.0	75		8.8	10.4
36	K	12	97	78				13.1	.142	95.7	35		7.8	11.3
46	K	5	98	91	45.7	40.0	34.3	18.0	.140	7.2		54	9.0	10.8
55	K	5	98	85	44.1	37.4	28.4	15.3	.140	50.9	35		7.7	9.0
74	K	7 1/2	84	81	44.1	34.9	21.0	13.5	.146	54.3	70		6.8	9.0
75	K	7 1/2	84	81	44.1	34.9	21.0	13.5	.146	53.8	42		6.5	9.0
Conoco T-60														
32	L	16	93	84				11.8	.148	3.0	7		8.6	15.1
53	L	16	100	90	44.9	38.6	18.4	12.6	.103	.5	2		7.6	14.2
68	L	16	99	92	41.6	36.9	13.4	11.5	.141	2.3	8		7.0	11.6
69	L	16	99	92	41.6	36.9	13.4	11.5	.141	1.5	5		6.0	11.0
84	L	16	94	95	40.8	35.1	16.6	8.6	.153	1.0	4		7.2	11.6
85	L	16	94	95	40.8	35.1	16.6	8.6	.153	1.0	2		6.2	10.0

* OS - Off Scale
Pad too bright to read

TABLE X

SUMMARY OF TEST RESULTS - 20 GPM LOOP

RUN NR.	TEST PROCEDURE	ADDITIVE	CONCENTRATION LBS/1000 BBLS	ELEMENT	SOLID CONTAMINANTS	MAX. H_2O PPM	SOLIDS (MG/L) AVG.	SOLIDS (MG/L) MAX.	ΔP IN PSI
110A	8901	Santolene C	16	C-2037-3		18			
110B	8901	Santolene C	16	I-4208	A. C. Coarse	20	0.21	0.42	32.0
111	8901	Santolene C	16	C-2037-3	A. C. Coarse	27			18.0
112	8901	Santolene C	16	C-2037-3		20			10.5
113	1st Hr. 8901	Santolene C	16	C-2037-3		6			10.3
114	1st Hr. 1% H_2O			C-2037-3		0			10.8
115	8901	Santolene C	16	600343	A. C. Coarse	11	0.04	0.16	20.5
116	8901	Santolene C	16	TE-497	A. C. Coarse	30	0.00	0.00	21.5
117A	8901	Santolene C	16	C-2037-3		9			8.3
117B	8901	Santolene C	16	600343		12			8.0
117C	8901	Santolene C	16	I-4208	A. C. Coarse	24	0.11	0.27	36.5
118	8901	Santolene C	16	045800-10	A. C. Coarse	2	0.42	0.94	50+
201	8901	Santolene C	16	045800-10	A. C. Coarse	11	0.38	1.00	28.5
202*	8901	Santolene C	16	C-2037-3	A. C. Coarse	3	0.37	0.54	19.5
203*	8901	Santolene C	16	C-2037-3	A. C. Coarse	5	0.06	0.40	16.0

* Runs 202 and 203 used distilled water in lieu of WPAFB tap water.

To determine if the corrosion inhibitor was at fault, a sample of Santolene C from the batch used in the original qualification tests on the elements was obtained from Ft. Belvoir; three consecutive coalescence failures occurred using three different elements (Test Numbers 117A, 117B, and 117C). MIL-F-8901B elements were also obtained from Bendix and the tests resulted in one marginal pass and one failure (Test Number 118 and 201). Since MIL-F-8901B qualified elements were consistently failing the MIL-F-8901B inhibited fuel test, a comparison test was run at Ft. Belvoir on a Banner element from one of the production lots that had failed on water removal at AFAPL. The results of this test were satisfactory with the only major differences between the AFAPL and Ft. Belvoir test being the tap water used as the test contaminant. The water at WPAFB is considerably harder with a higher pH than the Ft. Belvoir water and could cause a chemical reaction with the corrosion inhibitor. Two runs (202 and 203) were then made at AFAPL using the Banner elements, HITEC 515, and distilled water. Both tests were passes with good water coalescence and solids removal. (See Table X for these test results).

Starting with Run Nr. 204 (See Table XI) all eleven of the MIL-I-25017 corrosion inhibitors were tested using the inhibited fuel test of MIL-F-8901B with distilled water as the liquid test contaminant. The results are tabulated in Table XI. The test elements used were Bendix 045800-10, since there was not a sufficient quantity of the Banner elements to complete the testing. All the inhibitors passed the water removal part of the test using the pass/fail criteria of MIL-F-8901B (maximum free water allowed is 5 ppm when measured by the Turbidimeter). Water content of the effluent fuel was also measured using the Aqua-Glo Series II. Some individual readings were above 5 ppm, but the averages were all below 5 ppm.

The average solids content was below the limit of 0.5 mg per liter for all runs; however, on two runs (206 and 214), one solid sample exceeded the limit of 1 mg per liter for an individual sample. Since there were no visible solids on the Millipore pad and the remaining pads were well within the specification limits, the results of these pads were disregarded.

TABLE XI

MIL-F-8901B INHIBITED FUELS IN 20 GPM LOOP
USING DISTILLED TEST WATER

RUN NR.	ADDITIVE	CONCENTRATION LBS/1000 BBLS	MAX H_2O		H_2O BY AQUA GLO			SOLIDS		ΔP PSI		WSIM			FSII	
			TURBIDOMETER PPM	TOTAMETER PPM	MIN PPM	MAX PPM	AVG PPM	MAX. MG/1	AVG. MG/1	INITIAL	MAX	BASE FUEL	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST
204	Hitec 515	16	1.4	1.0	1.8	4.0	2.6	0.74	0.31	4.5	11.0	99	84	84	0.141	0.004
205	Lubrizol 541	3	0.5	0.5	1.7	3.5	2.3	0.35	0.15	4.5	11.0	99	90	97	0.110	0.173
206	PRI-19	4	1.3	1.2	2.0	5.2	3.2	1.25	0.20	6.0	15.5	93	86	96	0.146	0.053
207	Tolad 245	7 1/2	1.8	1.5	3.5	4.6	4.0	0.08	0.01	4.0	12.3	100	89	96	0.148	0.054
208	Nalco 5400	4 1/2	0.9	0.7	2.5	5.5	3.9	0.75	0.16	4.3	18.5	98	88	93	0.169	0.054
209	Conoco T-60	16	0.6	0.5	2.6	4.0	3.1	0.16	0.02	5.0	19.0	100	95	97	0.143	0.043
210	AFA-1	4 1/2	0.5	0.3	2.8	5.2	3.5	0.14	0.03	6.1	20.5	100	87	87	0.173	0.042
211	Tolad 244	4 1/2	0.5	0.2	1.7	2.8	2.1	0.12	0.02	4.3	16.5	99	63		0.143	0.046
212	DCI-4	8	0.7	0.3	2.0	5.0	2.5	0.23	0.07	5.8	18.8	98	88		0.140	0.050
213	Unicor J	8	0.5	0.3	1.8	6.0	3.4	0.18	0.08	4.8	18.5	100	83	74	0.150	0.060
214	Hitec 534	8	0.6	0.4	2.5	6.0	3.9	1.07	0.16	4.5	11.5	100	47	45	0.155	0.042

TABLE XI (CONCLUDED)

RUN NR.	INTERFACIAL TENSION, DYNES/CM						SURFACE TENSION		pH		INJ H_2O SOLIDS MG/LITER	ELEMENT WEIGHT CHANGE GRAMS
	BASE vs DIST H_2O	PRETEST vs DIST. H_2O	PRETEST vs INJ. H_2O	POST-TEST vs DIST. H_2O	POST-TEST vs INJ. H_2O	POST-TEST vs SUMP H_2O	INJ. H_2O	SUMP H_2O	INJ. H_2O	SUMP H_2O		
204	47.5	36.6	36.7	38.3	34.2	18.1	70.8	46.6	6.4	6.3	0.0	
205	45.0	37.4	37.7	38.2	37.3	22.9	69.8	52.3	5.8	5.8	0.4	185.3
206	45.4	36.5	33.9	37.3	32.6	28.7	59.8	56.3	6.5	6.2	0.0	175.5
207	45.7	32.5	33.4	37.0	34.5	19.1	71.1	42.5	6.1	6.3	0.0	190.8
208	46.0	30.0	32.0	31.5	30.1	17.5	68.5	41.8	6.5	6.6	0.0	204.0
209	45.7	39.7	39.2	34.4	34.4	27.6	70.9	57.3	7.3	7.6	0.0	185.2
210	44.7	31.5	33.2	32.1	33.3	20.2	71.1	44.0	6.9	6.4	0.0	198.5
211	43.3	34.4	38.4	35.0	38.2	23.6	72.0	52.9	7.3	6.9	1.2	
212	42.1	32.5	38.9	37.4	35.3	23.7	45.8	50.8	7.4	7.0	0.8	259.3
213	40.8	39.9	37.3	37.6	30.2	27.2	67.7	56.8	7.3	7.1	39.8	198.2
214	42.6	37.8	39.3	39.6	37.1	20.2	71.5	48.2	8.2	7.5	9.6	140.2

Based on these test results, the MIL-I-25017 corrosion inhibitors, at the concentrations tested, seriously degrade the performance of filter separators when tested with WPAFB tap water but not when tested with distilled water.

SECTION V

CONCLUSIONS

Interactions may occur among fuel additives, the filter separator element, and fuel contaminants which affect the ability of the filter separator to remove the contamination.

Filter separator elements used by the Air Force are qualified to MIL-F-8901B and must pass various tests. However, these specification tests may not be truly representative of conditions that an element will encounter in the field.

The filter-separator elements are able to remove distilled water (i.e., rain or surface water) and up to a Type B medium hard water, such as that found at Ft. Belvoir, Virginia, where qualification tests are run, from fuel containing additives. When a Type C hard water such as that found at Wright-Patterson AFB, Ohio is encountered, the filter element may or may not be able to remove the water depending on what interactions may occur among the element, water and additive.

Fuel corrosion inhibitor additives will affect the solids holding capacity of an element and can reduce it by as much as 50 percent. None of the presently qualified filter-separator elements will remove red iron oxide from the fuel containing a corrosion inhibitor; however, this capability is definitely within the state-of-the-art.

REFERENCES

1. Johnston, R. K., et al, Effect of Corrosion Inhibitors on Fuel Behavior in Filter-Separator Life Tests, AFAPL-TR-70-7, March 1970.

2. McLaren, G. W., Krynitsky, J. A., and Hazlett, R. N., Effect of Corrosion Inhibitor on Jet Fuel Filtration, NRL Memorandum Report 1666.

3. Johnston, R. K., et al, Variables Affecting the Performance of Jet Fuel Filter-Separators, AFAPL-TR-70-36, June 1970.

4. Johnston, R. K., et al, Design of a Filter-Separator Test Facility for Research on Fuels and Equipment, AFAPL-TR-68-69, June 1968.

5. Johnston, R. K., Brown, R. D., and Monita, C. M., Hydrocarbon Fuel Handling and Contamination Control, AFAPL-TR-69-30, April 1969.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Air Force Aero Propulsion Laboratory Wright-Patterson AFB, Ohio 45433	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

EFFECTS OF FUEL ADDITIVES ON THE PERFORMANCE OF FILTER-SEPARATORS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report July 69 to June 72

5. AUTHOR(S) (First name, middle initial, last name)

Paul C. Linder

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1974	44	5

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 3048 c. Task 304805 d.	9a. ORIGINATOR'S REPORT NUMBER(S) AFAPL-TR-73-97 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

AUG-1974

Distribution limited to U. S. Government agencies only; Test and Evaluation; [redacted] Other requests for this document must be referred to AFAPL/SFF.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Air Force Aero Propulsion Laboratory Wright-Patterson AFB, Ohio 45433

13. ABSTRACT

The effects of fuel corrosion inhibitors on the coalescencing performance of filter-separators were evaluated using a small 1.3 gpm test loop. These tests showed that corrosion inhibitors presently qualified to MIL-I-25017 differed significantly in their deleterious effects on coalescence when tested using Wright-Patterson AFB tap water as the free water contaminant.

Single element tests using DOD standard filter-coalescer elements and a 20 gpm test loop showed: (1) filtration performance is affected by the type of solid contaminant used, the type and quantity of corrosion inhibitor, and the brand of filter-coalescer element used; and (2) coalescence performance can be significantly affected by the purity of free water (i.e. dissolved solids) when the fuel contains a corrosion inhibitor and fuel system icing inhibitor.

DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aviation Fuels						
Filter Separator						
Fuel Additives						
Contamination						

UNCLASSIFIED

Security Classification

*U.S.Government Printing Office: 1974 — 657-014/152